WATERSHED PROCESSES AND WATER RESOURCES

Panel Manager - Dr. Don Scott, University of Arkansas
Program Director - Dr. Michael O'Neill

A sustainable and reliable source of fresh water in both natural and managed watersheds is vital for the continued production of food and fiber. Research in the Watershed Processes and Water Resources Program is aimed at two interrelated areas: (1) Understanding the fundamental processes and watershed characteristics controlling the origin, transport, and fate of water, sediment, nutrients, dissolved matter, and biological organisms from forests, rangelands, and agricultural environments and (2) Developing management and technology for consumptive and non-consumptive uses that affect quantity and quality of water in agriculture and forestry production.

2000-00963 Development of Guidelines for Fertigation in Surface Irrigation Systems

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Grant 2001-35102-10218; $192,5003; Years

Each year a significant amount of nitrogen fertilizer is injected into the water applied to surface irrigated crops. This method of fertilizer application, known as fertigation, allows growers a convenient and flexible way to apply nutrients to crops during any part of the season and offers economic advantages over traditional fertilizer methods in terms of reduced labor, energy, and farm-machinery costs. Although fertigation is widely practiced for surface irrigated crop production systems in the western U.S., appropriate management criteria for the practice have not been established. Inefficient nitrogen fertigation practices can result in nitrate contamination of groundwater through deep percolation and of surface water through tail water runoff. Protecting water resources from nitrate contamination is of great concern because of the associated health effects related to nitrate ingestion in mammals, such as blue baby syndrome and stomach cancer in adults. The purpose of this project is to develop management guidelines for fertigation in surface irrigation systems. This will be derived through a series of fertigation experiments conducted in farm-scale fields under representative surface irrigation systems in the western U.S. The appropriate timing and duration of nitrogen injection during an irrigation will be determined in order to provide uniform nutrient distribution to the crop and minimize the nitrate leaching and runoff losses. Data derived during this project Will be used to develop and validate components needed for existing soil-water and surface irrigation models, which will allow more comprehensive evaluation of fertigation practices and an expansion of guidelines for conditions and irrigation systems other than those encountered in the project.

2000-00911 Simulation and Validation of Phosphorus Loading in Furrow Irrigation Tailwater

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Grant 2001-35102-09931; $195,000; 3 Years

Phosphorus (P) is an essential nutrient for terrestrial and aquatic plants. The beneficial effects of P on crop growth and yields are well documented. Phosphorus is also associated with environmental pollution when critical concentrations are exceeded, causing excessive algae and aquatic vegetation growth leading to eutrophication. Agriculture is designated as the primary source of P entering inland streams, lakes and water impoundments. The main method by which phosphorus leaves agricultural fields is attached to eroded soil particles, induced either by rainfall or irrigation. We currently have a computer simulation model that predicts the flow of water over the soil surface during surface irrigation events. In this research project, we will add the ability to predict the movement (erosion) of soil particles and phosphorus (either dissolved in the water or attached to soil) during surface irrigation events. The amount of water, sediment, and phosphorus that leave the field are influenced by the soil and how the irrigation system is designed and operated - that is, what flow rate is chosen, whether it varies with time, and how long the water runs into and

off the field. The mathematical simulation model will allow one to examine different options for operating the irrigation system and be able to predict resulting differences in phosphorus leaving the field. The model can then be used to either predict phosphorus loading from various surface irrigation systems or to provide recommendations to surface irrigation farmers for reducing phosphorous loading.

2000-00879 Electrokinetic Management of Nitrate Movement in Drip Irrigated Soils
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Larson, D.L.; Walworth, J; Slack, D.C.
Grant 2001-35102-09878; $112,000; 2 Years

Widespread application of nitrogen fertilizers to maximize crop production has resulted in serious water contamination threats. Nitrogen is highly water soluble and very mobile in soil and therefore subject to leaching through soil into underground or adjacent bodies of water.

Electrokinetic processes can control the movement of some chemicals in fluid or porous media and have been used effectively to concentrate metals and organic chemicals for removal from soils in some commercial decontamination applications. Prior agricultural research found an electrical potential could increase salt removal in soil desalination leaching.

Prior University of Arizona field lysimeter studies found nitrates could be concentrated near the anode. A USDA funded study commencing in November will evaluate the management of nitrate movement and changes in soil acidity resulting from application of a small dc electrical potential in subsurface drip irrigated crop production.

2000-00943 Optimization of Water and N for Surface Irrigated Production Systems
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University of Arizona; Yuma Agncultural Center; Yuma, AZ 85364
Grant 2001-35102-09880; $227,000; 3 Years

The low desert region of southwestern Arizona and southern California represent more than 300,000 hectares of irrigated cropland. This area produces more than 90% of the nation's salad vegetables and a significant portion of the nations citrus shipped during the winter months. Surface irrigation is the principal irrigation method for horticultural production systems of the low desert region. In addition, owing mainly to its cost effectiveness and flexibility, the application of N fertilizer via irrigation (fertigation) is widely practiced. Inefficient irrigation and N-fertigation operations contribute to excessive water and nitrogen loss from irrigated lands as well as to nitrate contamination of water resources. Substantial improvement in water use efficiencies can be realized through the use of improved irrigation system design and management approaches. However, approaches are inadequate in the context of integrated resource management operations, such as fertigation. This project seeks to develop new design and management approaches and guidelines for the N-fertigation system in surface irrigation setting through experimental and modeling studies. Field experiments will be performed to develop a database for the calibration and validation of the surface hydraulics and chemical transport models. The nitrogen transport models, coupled with a surface irrigation simulation model will be used to develop improved management guidelines for the N-fertigation operations for low desert horticultural production systems. It is anticipated that the implementation of irrigation and N management practices developed and demonstrated in this project will result in more efficient water utilization, reduced nitrate-N leaching, and reduced salt loading to surface waters.

2000-00958 Ground Penetrating Radar: Development of a Vineyard Management Tool
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Grant 2001-35102-09866; $250,000; 3 Years

There are currently no techniques available to yield information about soil heterogeneities and water content at both the resolution and spatial coverage needed to assist crop development and management, and in particular, vineyard management. Prompted by successful results of a controlled ground penetrating radar (GPR) pilot study, we propose to test the applicability GPR methods to interpret soil variabilities and to estimate water content under real field conditions at a study site within the Robert Mondavi vineyards in Napa County, California. GPR is a surface-based geophysical tool that uses high frequency electromagnetic energy to probe the subsurface. Variations in electromagnetic properties, inferred from changes in the recorded signal, can be indicative of soil texture or water content variations in both the lateral direction as well as with depth. GPR methods perform optimally over the rooting depth and moisture content ranges common for grapevines, and has the capability to provide the necessary soil and water content information in multi-dimensions, with high resolution, and in a non-invasive manner. Detailed soil variability and water content at a vineyard site could assist in estimation of plantable acreage, in the design of vineyard layout and in the design of a more efficient irrigation scheme. Our current research involves investigation of GPR acquisition, inversion and interpretation techniques under different field conditions to determine the viability of this method as a reliable and efficient water-content field tool. A natural extension of the successful development of the GPR tool is to other crops, especially in semi-arid or arid environments.

2000-00973 Economic and Hydrologic Trade-offs Between Water Consumption and Groundwater Recharge for Cover Cropped Systems

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Grant 2001-35102-09858; $171,000; 3 Years

Cover cropping builds soils, increases water infiltration, diversifies crop rotations, and protects soils from wind and water erosion. However, cover crops can compete with cash crops for limited moisture, and have therefore not been widely used in California's irrigated row crop systems. If more surface water had to be diverted to agriculture in order for cover cropping to be practiced in California, less would be available for fisheries and other publicly desired resources. On the other hand, if cover-cropping resulted in significant groundwater recharge through greater capture of winter rainfall, it might be possible for farmers to use groundwater for part of their irrigation needs and divert less surface water to agriculture. This project will investigate tradeoffs between water consumption and groundwater recharge at the field level in two ongoing experiments in California's Central Valley, the Sustainable Agriculture Farming Systems (SAFS) Project and Biologically Integrated Farming Systems (BIFS) Project. These projects are comparing cover-cropped systems with conventional systems in terms of soil quality, pest management, and other important biological parameters. Water budgets developed at the filed level will then be used to quantify, with the Geographic Information System ARC/INFO as well as hydrology models, water consumption, infiltration, and groundwater recharge at the landscape or watershed level if cover-cropping were adopted on a large scale.

2000-00829 Fate of Nitrogen During Transport Through Agriculturally Impacted Rivers

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Grant 2001-35102-09870; $277,000; 3 Years

Nitrogen contamination of surface waters is an undesired side effect and a key concern for many agricultural practices in the U.S. Although transport of nitrogen by the Mississippi River has been suggested to be a contributing factor in the development of a hypoxic zone in the Gulf of Mexico, little is actually known about the net effect of instream processes on nitrogen transport in small and medium sized rivers. The goal of this project is to conduct a detailed, multidisciplinary investigation of denitrification (microbial reduction of nitrate to nitrogen gas) and nitrification (microbial oxidation of ammonium to nitrate) in two agriculturally-impacted rivers in Indiana and Illinois. The rivers differ in size, flow, and bed sediment

characteristics. The project is designed to repeatedly sample a parcel of water as it travels downstream to characterize and quantify nitrogen-containing compounds to determine the overall effect of denitrification and nitrification on riverine nitrogen loads, nitrogen speciation, nitrogen isotope geochemistry, and trace constituent concentrations. This approach requires careful characterization of stream hydrology; depth and width integrated discharge, flow, and tributary inputs. In-stream tracer studies will be used to quantify the extent of water exchange between the river channel and river-bank and bed-sediment pore water. Additionally, the nitrification and denitrification processes will be measured directly using a variety of techniques. These will include incubation techniques with stream-bed cores, quantification of within stream nitrogen/argon ratios, and molecular probe characterization of the microbial populations responsible for each activity. This study will provide one of the first comprehensive examinations of nitrification and denitrification in streams, from the perspective of nitrogen loads, and should facilitate evaluation of the role of these processes in mediating or mitigating transport of nitrogen to coastal receiving waters. The results should greatly improve the reliability of regional transport models that simulate nitrogen discharge in rivers draining agricultural areas.

2000-00831 Coastal Eutrophication and the Productivity if Clams and Oysters

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Grant 2001-35102-09857; $435,000; 3 Years.

Anthropogenic activities in a watershed can have significant impacts on the ecology of downstream coastal environments. The Suwannee River drains 28,500 km2 of southern Georgia and north central Florida. Surface runoff and groundwater inputs contribute high levels of nutrients to this blackwater river before it discharges into the region of the Gulf of Mexico known as the Big Bend. The Big Bend is extensively harvested for oysters and is the site of a newly emergent aquatic agriculture industry, clam aquaculture. The growth and stability of this industry hinges on maintaining a balance between the nutrients that contribute to productivity and excessive eutrophication that can lead to destructive phenomena like blooms of harmful algae and bacteria. The central goal of our research plan is to define the relationship between coastal eutrophication and the productivity of clams and oysters. A clear understanding of this linkage forms the basis for evaluating the consequences of future trends in loading to the watershed. It is essential that a clear understanding of the relationship between cultural eutrophication and the ecology of these important marine resources be developed to ensure the future viability and growth of these aquatic agricultural industries.

2000-00949 Fate and Transport of Estradiol, Testosterone from Poultry Litter Applied to Tilled and Non-Tilled Cropping Systems

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Grant 2001-35102-10219; $214,000; 3 Years

As progress has been made under the Clean Water Act, concern has shifted to non-point sources of water pollution. Agriculture has been identified as a dominant source of non-point source of pollutants. In 1998 the U.S. poultry industry produced over 13 million tons of broiler litter most of which was applied to agricultural lands. Little is known about the concentrations of the sex hormones estradiol and testosterone, both of which may pose a public health risk, in runoff and subsurface drainage from fields amended with broiler litter. These sex hormones will be studied under two different tillage systems: conservation tillage which is being promoted world-wide, and conventional tillage. Our objectives are (1) to determine estradiol and testosterone concentrations, in surface and subsurface runoff from conservation tillage and conventional tillage soils to which fresh broiler litter is applied; (2) to determine the transport characteristics and degradation rates of these hormones in litter, soil, and environmental water samples. This research will be

conducted at the USDA-ARS Water Quality Research Site near Watkinsville, GA. It is instrumented for studying runoff and leaching problems, and has conventional and conservation tillage plots established in 1991. Transport characteristics and rates of degradation of the hormones will be investigated using intact columns and environmental soil and water samples. The results should indicate the extent to which the hormones from broiler litter are a problem in runoff and subsurface drainage. This research will provide information that will identify and reduce risks associated with confined, large-scale animal production.

2000-01147 Use of a Gas Chromatograph/Mass Spectrometer for Trace Chemical Analysis

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Equipment Grant; Grant 2001-35106-09890; $36,450; 1Year

The goal of this project is to acquire and efficiently use a gas chromatograph with mass spectrometer (GC/MS) for the analysis and environmental assessment of trace chemicals in a variety of projects of the PIs. A GC/MS is required for the analysis of pesticide metabolites, priority pollutants that require GC/MS methods, and chemicals that require identification. These chemicals cannot be easily analyzed by a gas chromatograph (GC) for which the PIs have the facility. The institutional capability for GC/MS facilities at the University of Hawaii is minimal and coordination is often difficult. This also makes difficult to use a system for research since the available GC/MS systems are dedicated to service related work throughout the year. We have 10 ongoing projects in which a GC/MS could provide additional valuable data and enhance our project objectives. Acquisition of this GC/MS will lead to future collaboration among faculty from other department. We are hopeful that our enhanced capability will enable us to attract funding from local, state, and other federal agencies. We have proposed to provide 50% of the equipment purchase cost from our institutional sources. In addition, we have a permanent state-funded chemist (Mr. Lichwa) who is familiar with several USEPA methods for the analysis of environmental chemicals by GC/MS. We also propose to pay for the routine maintenance of the equipment through our funded projects and other institutional sources. The ability to conduct our own GC/MS analyses will allow us to be more competitive for external research support.

2000-01002 Real-Time Soil Nitrate Analysis System for Precision Nitrogen Application

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Grant 2001-35102-09879; $184,500; 3 Years

Over the last half century, agricultural production has increased dramatically due to the introduction of new hybrids, improved knowledge, mechanization, pesticides and chemical fertilizers. The widespread use of chemicals has increased the potential for environmental contamination, in particular nitrates and phosphates in aquatic systems, with associated human health risks and eutrophication. Researchers have reported that precision agriculture could reduce fertilizer use by 30% without any reduction in productivity, and has the potential to prevent the environmental contamination while maintaining world agricultural production. However, the full benefit of precision agriculture will only be realized if the spatial variation across the field is accurately determined. This requires the development of sensors which will allow the collection of data on a much finer spatial resolution, to more accurately characterize within-field variability.

The goal of this project is to develop a real-time soil nutrient analysis system. The project focuses on a soil nitrate sensor, due to the economic importance of these fertilizers and the potential environmental problems associated with high nitrate levels in water. However, the proposed analysis system could be adapted to sense many other soil nutrients and even used for the simultaneous analysis of multiple nutrients. A real-time soil nitrate sensor used in conjunction with established soil nitrate test recommendations, such as the pre-sidedress nitrate test (PSNT) could have a significant impact on fertilizer application. There is

potential for reduction in fertilizer inputs with negligible reductions in yield, while reducing the potential for environmental degradation due to excess nitrate in the environment.

2000-00918 Modification and Evaluation of SWAT Model for Artificially Drained Watersheds

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Grant 2001-35102-09861; $129,000; 2 Years

States will be required to identify surface waters impaired by excess nutrients and develop total maximum daily loads (TMDLs) for nutrients in these impaired watersheds. Proper TMDL calculations will require accounting for nutrients derived from all sources, including agriculture, and may lead to mandated reductions in fertilizer use. Because stream databases are poorly developed for most watersheds, computer models will be relied upon for the determination of both TMDLs and the identification of best management practices for pollutant reduction efforts. To be affective, these models must accurately predict water flow and nutrient loads within complex watersheds, which will require the accurate description of all major hydrologic processes operating within a watershed. Currently, there are no watershed-scale models that include the effect of subsurface drainage tiles. This is especially important for much of the Midwest corn belt where 50% of the crop land in some states is drained by tiles. In this research, we will modify the extensively used computer model SWAT, to specifically include the effects that tiles have on surface hydrology and nutrient fate and transport. Once modified, we will evaluate the model for its accuracy and reliability in predicting stream flows and nitrate concentrations. This testing will use the multi-year data set being collected on Walnut Creek in central Iowa - a stream contamination by nitrate due to agricultural activity in a watershed dominated by tile drains. This data set includes stream flow and nitrate concentration measurements covering a seven year period. After testing, the revised SWAT model will be made available to water resource professionals.

2000-00909 Soil Biogeochemical Indicators to Assess Water Quality in Wetlands

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Strengthening Award; Grant 2001-35102-10046; $130,000, 3 Years

Agriculture has contributed to significant losses and impairments of wetlands in the United States, which has restricted many of their beneficial uses as drinking water, recreational, and wildlife habitat resources. To offset these problems, there is interest in creating and restoring wetlands to fully functioning systems. Unfortunately, there is a paucity of information about how wetlands function which is largely due to a lack of practical tools to assess them.

One approach that is gaining widespread support to assess wetland functions is the Hydrogeomorphic, or the (HGM) Classification System. In the system, measurements are compared between mitigated wetlands and reference wetlands, which are used to calculate the Functional Capacity Index. Unfortunately, many variables of the HGM system are dissociated from the processes governing water quality, which compromises the scientific validity of the HGM system.

Wetlands attenuate agricultural pollutants, in large part through biogeochemical processes in the soil. Organic matter decomposition, nitrification, denitrification, and sorption are major pathways for water quality improvement, and are functions that regulate microbial activities and soil chemistry. These factors are referred to as biogeochemical indicators. In the proposed research, nutrient cycling processes, biogeochemical indicators, and the HGM system will be evaluated in a series of laboratory and *in situ* studies with soil and litter obtained from low-gradient, riverine wetlands, with the goal of linking actual wetland processes to biogeochemical indicators and HGM variables. Results will ultimately be useful by providing diagnostic tools to assess the water quality improvement function of created and restored wetland ecosystems.

2000-00856 Epidemiology of Bacterial Contamination of Surface Water by Manure

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Grant 2001-35102-09883; $270,000; 3 Years

Agricultural non-point source water contamination now accounts for a larger share of discharges than a decade ago. However, the extent to which surface water is contaminated by bacteria from livestock and poultry manure has yet to be determined, and there is little information on the effect of specific manure management practices. The goals of this study is are to develop a low-cost means of identifying sources of water contamination and to apply these data to an epidemiological study of manure management risk factors.

Antibiotic sensitivity profiles of *E. coli* (bacteria) isolated from surface water in the Mid-Atlantic and Midwest will be compared to those from fecal samples collected from livestock on surrounding farms, local wildlife, and septic tanks. The sources of the *E. coli* contamination of the water samples will be determined based upon statistical comparision (using discriminant function analysis) of the antibiotic sensitivity patterns of the bacteria from the water samples and those from the known sources. Statistical modeling (multivariable regression techniques) will also be used to identify manure management practices associated with fecal contamination of surface water.

This study will determine: 1) the accuracy of discriminant function analysis as a tool for monitoring the sources of water contamination; 2) the extent to which the sampled watersheds are contaminated by livestock fecal *E. coli*; and 3) the manure management practices associated with increased water contamination. The results will be used to develop a manure management extension education program to promote protection of surface water from bacterial hazards in manure.

2000-01000 Diamond Microelectrode Arrays: New Materials for the Electrochemical Detection of Aqueous Analytes

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Grant 2001-35102-10045; $271,000; 3 Years

This research project will focus on the fabrication**,** physical and chemical characterization, and electrochemical evaluation of conductive, boron-doped diamond microelectrode arrays (pyramids, disks and columns) for use as electrochemical detectors in flowing streams. Several environmental toxins important in agriculture wil1 be targeted. Diamond is a new electrode material that has been shown to possess superb properties for electroanalysis. It is anticipated that diamond will provide significant improvements in the detection figures of merit (dynamic range, limit of detection, sensitivity, response precision and response stability) for these analytes, compared to what can be achieved with existing electrode materials and technololies. These improvements are anticipated because of the material's unique properties coupled with the advantages resulting from the micrometer to nanometer sized electrodes geometies. Diamond microarray detectors could open new frontiers in electroanalysis and electrochemical-based sensors.

The microelectrode arrays will be used as electrochemical detectors coupled with flow injection analysis and liquid chromatography to stably and reproducibly detect both “pure” and “real world” samples of heavy metal ions (PB^{+2}, Cd^{+2}, Hg_{+2}, and Zn^{+2}). In general the largest detection figures of merit will be (1) a linear dynamic range or at least 5 orders of magnitude from 100 ppm to 0.1 ppb, (2) a concentration limit of detection of 0.1 ppb (20 μL injection) at a S/N = 3, (3) a response precision of 2% or less for 20 consecutive injections at the 1 ppb level, and (4) a response stability of better than 95% over 5 days of continuous use. The arrays will also be used for the detection and remediation of phenol and chlorinated phenols via electrooxidation.

2000-00876 Effect of Phosphate Metabolism on Phosphorus Levels in Aquaculture Effluents
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Department of Pharmacology and Physiology; Newark, NJ 07103-2714
Grant 2001-35102-09881; $324,000; 3 Years

Effluents from aquaculture may contain excessive phosphorus levels. Although phosphates are needed for bone mineralization, utilization of dietary phosphorus by fish is low, and much is lost in the fecal matter and urine. To prevent eutrophication of public waters, the amount of effluent phosphorus that can be discharged from fish farms is strictly limited, potentially reducing production capacity. The long term goal of this proposal is to reduce the phosphorus content of aquaculture effluents by improving utilization of dietary phosphorus, identifying the metabolic sources of effluent phosphorus and understanding how environmental variables modulate effluent phosphorus production. Unfortunately, little is known about phosphate metabolism in fish, including rainbow trout. Preliminary work discovered (1) the presence of phosphate transport systems in trout kidney and intestine, the major organs responsible for recovering phosphates from urine and fecal matter, respectively, and (2) the partitioning of effluent phosphorus into soluble, suspended and settleable components, each of which varies according to dietary phosphorus and vitamin D concentrations. The objectives are to determine (1) whether alterations in dietary phosphorus and vitamin D concentrations can enhance dietary phosphorus utilization, reduce effluent phosphorus, and modify effluent phosphorus partitioning; and (2) the effects of water temperature and oxygen concentration on utilization efficiency and effluent levels of phosphorus. Accomplishment of project objectives will address gaps in our knowledge of phosphate metabolism and will contribute to effective changes in feeding practices and diet design that, once adopted, will reduce aquaculturally-derived water pollution and remove a major bottleneck in aquaculture production.

2000-00915 Denitrification in Rivers: A New Method to Test for Controlling Factors
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Postdoctoral Fellowship; Grant 2001-35102-09932; $88,500; 2 Years

Much of the nitrogen transported by rivers is derived from agricultural activity and atmospheric deposition. Nitrogen pollution derived from these sources can have significant impacts on receiving waters, degrading water quality and contributing to coastal eutrophication. Microbial denitrification can potentially remove much of the nitrogen input to rivers, buffering the effects of nitrogen pollution in aquatic ecosystems. It is believed that riverine denitrification is related to hydrologic characteristics of rivers, such as water retention time and discharge. Testing the importance of these factors is complicated because there are currently no methods to directly quantify denitrification in rivers. I propose a novel approach for directly quantifying denitrification in rivers (i.e., measuring production of an endproduct). I expect that the dissolved N_2 concentration in river water will be a function of N_2 production (via denitrification) and atmospheric exchange of N_2. I will measure dissolved N_2 concentrations and will experimentally determine atmospheric N_2 exchange rates to determine the denitrification rate. I will use this method to begin testing the importance of hydrologic characteristics (discharge and retention time) for regulating denitrification in rivers.
Rivers are also a major source of the greenhouse gas nitrous oxide (N_2O). Nitrous oxide is produced as a byproduct of microbial nitrification and denitrification. Improving estimates of denitrification in rivers and determining factors controlling denitrification are important for predicting N_2O production and formulating strategies to limit emissions. Nitrous oxide production in rivers will be determined from dissolved N_2O concentrations and experimentally determined atmospheric exchange rates of N_2O.

2000-01303 Equipment Grant: Purchase of a HP-5973 Mass Selective Detector System
Miller, G.C.

University of Nevada; Center for Environmental Science and Engineering; Reno, NV 89557
Equipment Grant; Grant 2001-35106-09936; $46,324; 1 Year

The proposed instrument will be used for a variety of projects which require the sensitive, specific and accurate measurement of chemicals in a variety of environmental and biochemical systems. The instrument proposed is a gas chromatograph-mass spectrometer (Hewlett Packard 5973 Mass Selective Detector) and is currently considered one of the most reliable, sensitive and user friendly instruments available for measuring organic chemicals. For both organic agricultural chemicals and biochemicals, this system has the capability of separating complex mixtures, identifying small amounts of each chemical and measuring the amount of the chemical present. In the near future this instrument will become the key system for measuring pesticides in the atmosphere and water, other organic pollutants in water and a variety of organic compounds in biological systems that are amenable to this method. Two specific immediate agricultural projects that will utilize this instrument are the determination of the fate of pesticides in the atmosphere and determining which type of chemicals are released by watercraft into recreational lakes. Both projects require the capabilities of this mass spectrometer. Biochemical uses include the determination of chemicals that insects use to communicate, and also to determine certain chemicals in insects that may increase our ability to manage insect populations. Future projects include measurement of chemicals released into surface and groundwater from septic and sanitary sewers systems. These include consumer chemicals and drugs that affect the quality of rural groundwater systems, particularly in those areas that utilize septic sewer systems.

2000-00919 Estimating the Risk of Water Contamination by *Cryptosporidium Parvum* Oocysts and other Colloidal Pollutants

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Grant 2001-35102-09871; $210,000; 3 Years

Many municipalities world-wide provide their citizens with finished drinking water whose source is surface waters. Recent outbreaks of cryptosporidiosis, particularly the massive outbreak in Milwaukee, Wisconsin in 1993 (403,000 people affected, 100 dead) raise grave concerns about the surface water quality and watershed management of the risk of contamination by pathogens.
Cryptosporidium parvum is a protozoan found in high concentrations in animal feces. The high intensity agriculture (e.g. cattle feedlots, land application of sewage and manure) may be the source of these pathogens in drinking water. The transmissive form of *C. parvum*, its oocysts, is not eliminated by filtration and standard disinfection methods. *C. parvum* thus challenges the long-standing engineering approaches to public health risks from water supply contamination.
A major benefit of this project is that it will provide crucial knowledge on the risk of human exposure to *C. parvum*. The project will provide a better understanding of the risk of pathogenic contamination associated with agricultural and other land use practices. This will allow city planers and environmental regulators to knowledgeably develop guidelines for the management of biological contaminants in watersheds. Additionally, this work will result in a resource enabling water treatment managers to better determine the risks of pollution in extreme hydrologic events thereby affording them the opportunity of timely altering water treatment methods and thus avoiding the possibility of treatment failures and outbreaks of cryptosporidiosis.

Evaluation and Management of *Cryptosporidium parvum* and Phosphorus Contributions in the Town Brook Watershed

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Grant 2001-35102-09863; $172,500; 3 Years

The Surface Water Treatment Rule generally requires filtration tore move pathogenic microorganisms from drinking water supplies. New York City (NYC) was granted an exemption from this rule provided that an acceptable watershed program plan and protective measures can be achieved. It was recommended that NYC put its highest priority on improved methods for detecting pathogens, understanding pathogen transport and fate, and demonstrating that best management practices (BMPs) will remove pathogens. Since pathogenic *Cryptosporidium* is resistant to chlorination and has multiple infection routes between humans and animals, a major focus of this research will be on detection, transport, and on BMP methods for removal. Thus far, phosphorus (P) removal from the NYC water supply has received the most attention. Since P accelerates the growth of algae within freshwater streams and reservoirs, it is also important to find effective methods of decreasing P loads. The growth and decay of algae produces dissolved organic compounds that can form toxic byproducts when the water is chlorinated. Although there are numerous differences in *Cryptosporidiumand P*, we hypothesize that there are also several similarities in their source and transport behaviors from agricultural lands. As such, this proposal seeks to investigate the two simultaneously to reduce the losses from agricultural lands. The research will capitalize on the existing collaboration of scientists and landowners. The early involvement of landowners should facilitate their adoption of recommended practices so that agriculture may continue to thrive while NYC water consumers can be assured of a high quality water supply.

2000-01136 Characterization of Pool-Riffle Spacing and Pool Depth Along the Poultney River

Field, J.
Green Mountain College; Environmental Studies Department; Poultney, VT 05764
Equipment Grant; Grant 2001-35106-10225; $15,557; 1 Year

Grant funds will be used to purchase an electronic total station surveying instrument and accessories to study the impact of watershed practices on stream habitat in the Poultney River in Rutland County, Vermont. Watershed activities such as logging, agriculture, and urbanization can directly impact the physical characteristics of a stream channel (i.e., width, depth, substrate size, and meander dimensions) due to increased runoff and sedimentation. These physical changes in the stream channel in turn can adversely impact fish habitat and the habitat of other aquatic species. Throughout the nation, stream restoration is becoming increasingly important as a means of improving habitat along impacted streams. These projects, however, are often completed on a site-by-site basis without adequate knowledge of the existing watershed conditions or the predisturbance condition the project is trying to recreate. Consequently, many of these projects fail to provide the habitat elements intended in the original project design. The electronic total station will be used to establish how physical parameters, and therefore habitat conditions, along the Poultney River vary between disturbed and undisturbed areas. Establishing how these parameters vary with different levels of watershed disturbance will help guide future restoration and land use activities along the Poultney River and similar stream systems.

2000-01001 Assessing Nitrate Contamination in Ground and Surface Waters Using Neural Network, GIS, and Simulation Modeling

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Grant 2001-35102-10044; $265,500; 3 Years

Watershed approach to water resources management has taken on added importance for America's watersheds. The prediction of water pollution at watershed scale has two important characteristics. First, surface/subsurface processes require enormous amounts of spatially related data as inputs. Second, complex relationships between data sets are highly heuristic and are characterized by a great deal of uncertainty. These characteristics make it imperative to use the integrated technologies of Geographic Information Systems (GIS) and artificial intelligence (AI) in watershed water quality assessment. With a long-term goal of integrating AI with GIS and computer modeling into decision support systems for watershed studies, this

proposed research focuses on assessing nitrate contamination probability in well and stream waters in a Wisconsin priority watershed through the use of artificial neural network, GIS, simulation modeling, and a large field database. The study will address the relationship between land use and water quality, the interrelation between well and stream waters, the impact of nonpoint and point sources, and the quantification of uncertainty. This project meets the goal of the Watershed Processes and Water Resources Program in developing a better understanding of fundamental processes and watershed characteristics controlling nitrate fate in the watershed under study. The combined AI-GIS-modeling methodology pursued in this study for nitrate would be applicable to other water quality studies (such as pesticide contamination and phosphate runoff) and should be transferable to other watersheds in Wisconsin and the U.S.

2000-01248 A New Rapid Assessment Protocol for Evaluating Water Quality

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Seed Grant; Grant 2001-35106-10220; $72,292; 2 Years

For many years, the quality of water has been determined by collecting, counting, and comparing the number of spineless, large animals that are found on the bottom of polluted and non-polluted streams. This procedure is known as the quantitative method, which requires substantial effort to collect and count the animals. Recently, many biologists who work on these animals, have moved away from the laborious quantitative method and towards the rapid assessment protocols; these require far less effort for collecting the animals of study. They do not, however, reduce the amount of in-laboratory counting time. This proposed research will develop a rapid assessment counting protocol that will reduce the amount of in-laboratory counting time, but be just as accurate as the currently-used method of picking through all specimens collected from a stream. This new counting protocol will make use of the latest in sampling and assessment techniques, and will include intensive field tests to make sure it works properly. This method is expected to save at least 50% of the counting effort, thus making sampling more efficient. Non-technical workers from the public and private sectors can quickly learn to use this method, which will help them determine whether or not sampled streams may be polluted. Finally, this protocol will be ideally suited for use when continually monitoring many streams for the potential presence of pollutants, and will benefit agriculture by helping producers better adjust their pesticide and fertilizer applications to minimize non-point sources of pollution.